[0015] Another type of haptic effect that is typically provided on handheld portable touchscreen devices is a "click" vibration effect applied to the touchscreen to simulate a press of a button. Measurements of traditional mechanical buttons shows that a pleasing and satisfying button feel is characterized by short, crisp vibrations in the approximate >200 Hz range. In order to be most effective, the haptic vibration effect should be applied primarily to the touchscreen rather than the housing.

[0016] FIG. **1** is a sectional view of a cellular telephone **10** in accordance with one embodiment. Telephone **10** includes a touchscreen **14** that displays telephone keys and other functional keys that can be selected by a user through the touching or other contact of touchscreen **14**. Telephone **10** further includes a housing or body **12** that encloses the internal components of telephone **10** and supports touchscreen **14**. When a user uses telephone **10**, the user will typically hold telephone **10** by housing **12** in one hand while touching touchscreen **14** with another hand. Other embodiments are not cellular telephones and do not have touchscreens but are haptic devices with other types of input interfaces. Other input interfaces besides touchscreens may be a mini-joystick, scroll wheel, d-Pad, keyboard, touch sensitive surface, etc. As with a cellular telephone, for these devices there is a desire for a click sensation linked to the input interface and an alert vibration created on the entire device.

[0017] Touchscreen **14** is flexibly suspended/floated or mounted on housing **12** by a suspension **18** that surrounds touchscreen **14**. In one embodiment, suspension **18** is formed from a viscoelastic bezel seal gasket made of a foam material such as PORON®. In other embodiments, any other type of material can be used for suspension **18** as long as it can be "tuned" as disclosed below.

[0018] A Linear Resonant Actuator ("LRA") or other type of actuator **16** (e.g., Shape Memory alloys, Electroactive polymers, Piezoelectric, etc.) is rigidly coupled to touchscreen **14**. An LRA includes a magnetic mass that is attached to a spring. The magnetic mass is energized by a electrical coil and is driven back and forth against the spring in a direction perpendicular to touchscreen **14** to create a vibration. In one embodiment, actuator **16** has a resonant frequency of approximately 150 Hz-190 Hz. The resonant frequency is the frequency range where the acceleration responsiveness is at its peak. A controller/processor, memory device, and other necessary components (not shown) are coupled to actuator **16** in order to create the signals and power to actuator **16** to create the desired haptic effects. Different haptic effects can be generated by actuator **16** in a known manner by varying the frequency, amplitude and timing of the driving signal to actuator **16**. Vibrations may be perpendicular to touchscreen **14** or in another direction (e.g., in-plane). In one embodiment, vibrations along the screen surface (X or Y vibrations) are advantageous as they produce equivalent haptic information and also are distributed more evenly over the entire touchscreen due to inherent stiffness of the screen in those directions.

[0019] In one embodiment, suspension **18** is tuned so that it isolates housing **12** of device **10** from vibrations at the click frequency (>200 Hz) that are applied to touchscreen **14** to simulate button presses, but effectively passes vibrations to housing **12** at the alert frequency (~150 Hz), which should be approximately equal to the resonant frequency of actuator **16**, to create alert haptic effects. Suspension **18** can be tuned by, for example, varying the selection of material to get a desired property, varying the total cross-sectional area, varying the thickness, etc.

[0020] FIG. **2** is a graph of acceleration magnitude vs. drive signal frequency that illustrates the frequency response of telephone **10** after tuning suspension **18** in accordance with one embodiment. Curve **20** is the frequency response measured on housing **12** and indicates a resonant frequency (f_1) at the alert frequency (~150 Hz). Curve **30** is the frequency response measured on touchscreen **14** and indicates a resonant frequency (f_2) at the click frequency (>200 Hz or ~500 Hz).

[0021] In operation, haptic effect vibrations can selectively be played as click vibrations to touchscreen **14** only, while being substantially isolated from housing **12** by suspension **18**, in the case of key-press confirmations, by playing the effects at the click frequency. Similarly, haptic effect vibrations can be selectively played as alert vibrations with vibrations that pass through to housing **12** with substantially no attenuation by playing the effects at the alert frequency.

[0022] FIG. **3** is a graph of acceleration magnitude vs. time for one embodiment for a click frequency (>200 Hz). In the embodiment of FIG. **3**, touchscreen **14** is suspended using two strips of PORON®, one along each edge, and an LRA with a resonant frequency of ~155 Hz. Trace **32**, which uses the scale on the left side of the graph, indicates accelerometer readings on touchscreen **14**. Trace **34**, which uses the scale on the right side of the graph, indicates accelerometer readings on housing **12** on the back of telephone **10**.

[0023] As shown, the vibration is predominantly experienced through the touchscreen by the pressing finger compared to through the housing by the supporting hand (5:1 acceleration ratio). Moreover, the click vibrations are fast reaching peak values ~3 ms after the start of the drive signal and decaying ~5 ms after the onset of braking. This is ideal for creating a crisp mechanical button feel.

[0024] FIG. **4** is a graph of acceleration magnitude vs. time for the same embodiment of FIG. **3** for an alert vibration frequency (~150 Hz). Trace **42**, which uses the scale on the left side of the graph, indicates accelerometer readings on touchscreen **14**. Trace **44**, which uses the scale on the right side of the graph, indicates accelerometer readings on housing **12** on the back of telephone **10**. Notwithstanding the touchscreen isolation through suspension **18**, the alert vibrations pass through to housing **12** and are experienced by the supporting hand almost without attenuation. This is ideal for creating effective alerts.

[0025] Several embodiments are specifically illustrated and/or described herein. However, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

[0026] For example, some embodiments disclosed above are implemented as a cellular telephone with a touchscreen, which is an object that can be grasped, gripped or otherwise physically contacted and manipulated by a user. As such, the present invention can be employed on other haptics enabled input and/or output devices that can be similarly manipulated by the user and may require two modes of haptic effects. Such other devices can include other touchscreen devices (e.g., a Global Positioning System ("GPS") naviga-